

Open Standards Based Platform for Digital Process Data

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Develop and demonstrate a prototype Additive Manufacturing (AM) Digital Supply Chain

PE #622147AF9 TASK # 1802

Other Transaction Agreement # W9124P-19-9-0001

AMTC-19-03-018 “Additive Manufacturing Technology Insertion in the Supply Chain”

Bi-directional, Secure digital transfer

Buyer



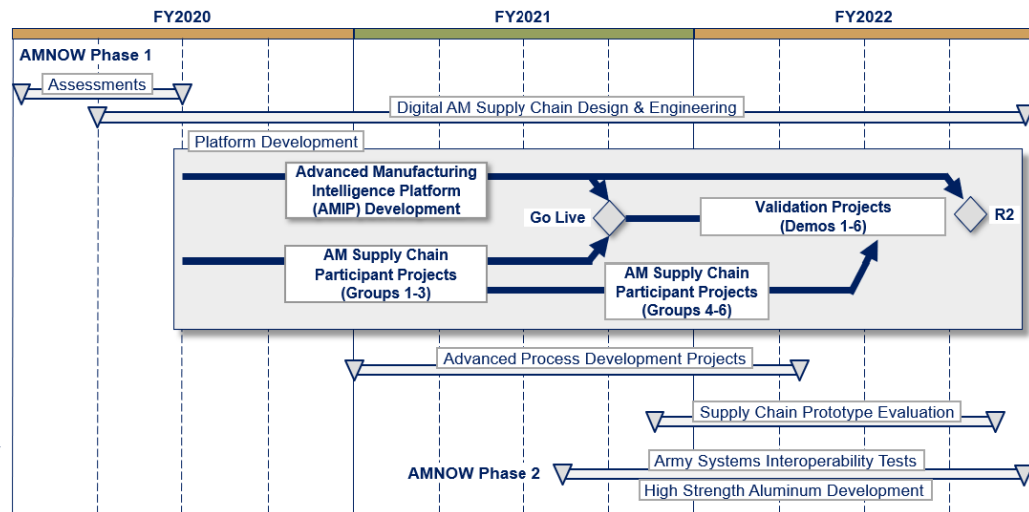
- Technical Data Packages (TDPs)
- Contracting Documents *(optional)*

Manufacturing process information:

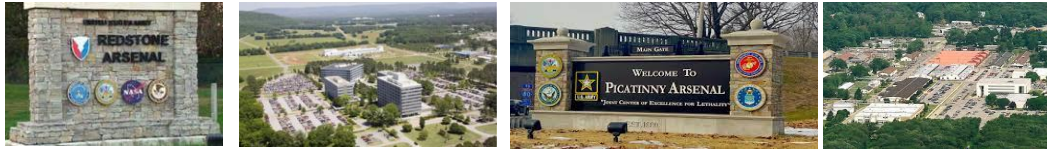
- In-situ time series controller data
- Post process data
- Digital Inspection data
- Test data



Supplier

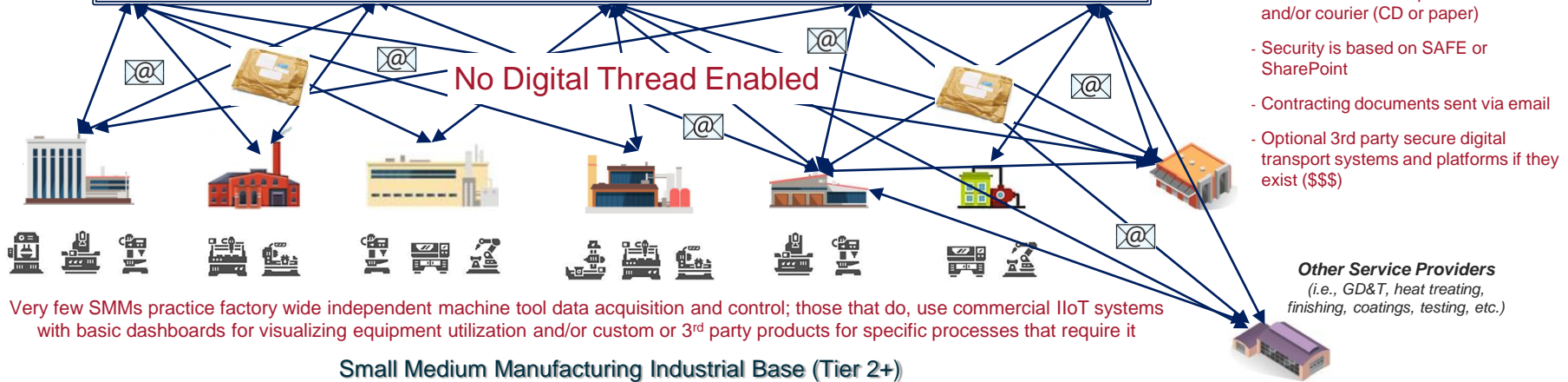


Army Facilities



Tightly Coupled and Secure Proprietary Digital Thread for Design & Technical Data

No Digital Thread Enabled



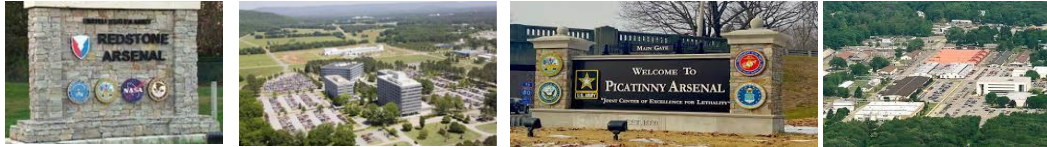
Current State

Army Procurement and their suppliers

- Technical data transported via email and/or courier (CD or paper)
- Security is based on SAFE or SharePoint
- Contracting documents sent via email
- Optional 3rd party secure digital transport systems and platforms if they exist (\$\$\$)

Army developed secure, non-proprietary, open standards based technical data transport platform

Army Facilities

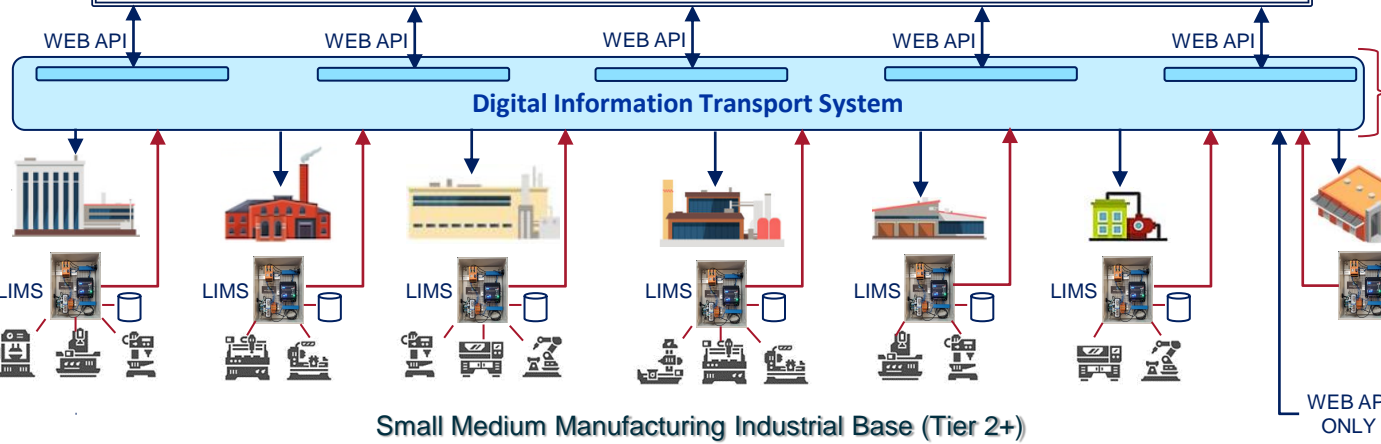


Tightly Coupled and Secure Proprietary Digital Thread for Design & Technical Data

Future State

Army Procurement and their **connected** suppliers

- Highly secure FIDO authentication
- All technical data digitally transported
- Contracting documents via email is OK
- Segregated secure zones using hardware encryption & tokenization
- Data exposure controlled via User Profile
- Open standards based, non-proprietary



Other Service Providers
(i.e., GD&T, heat treating, finishing, coatings, testing, etc.)

Buyer Organization Intranet

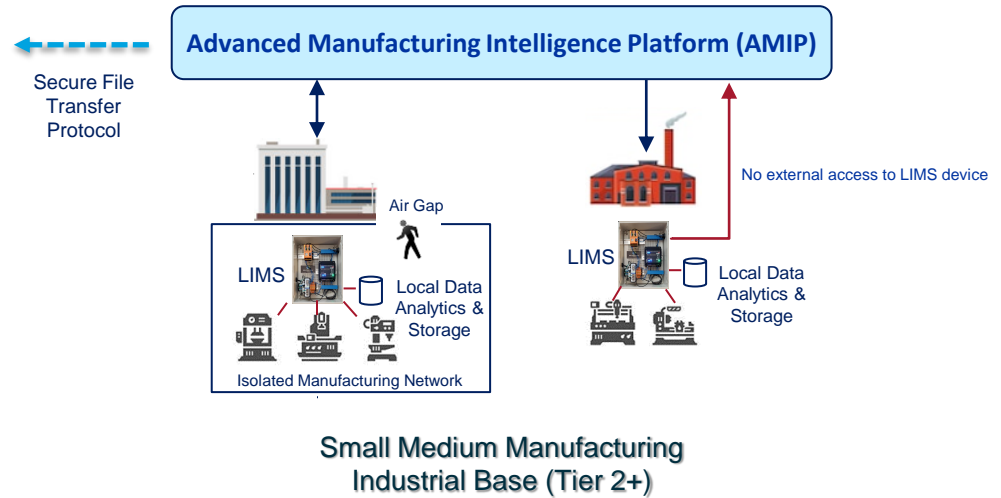


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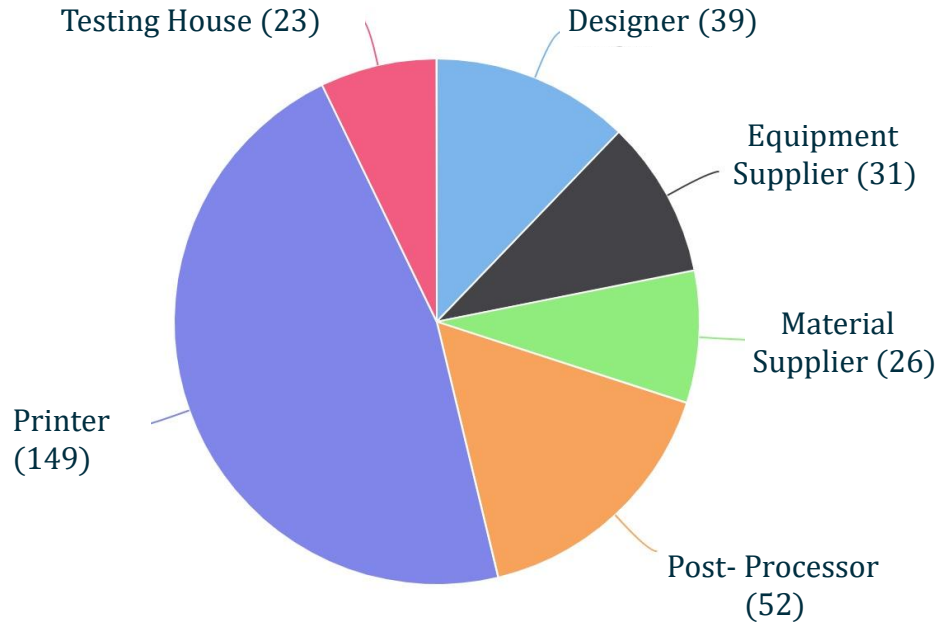
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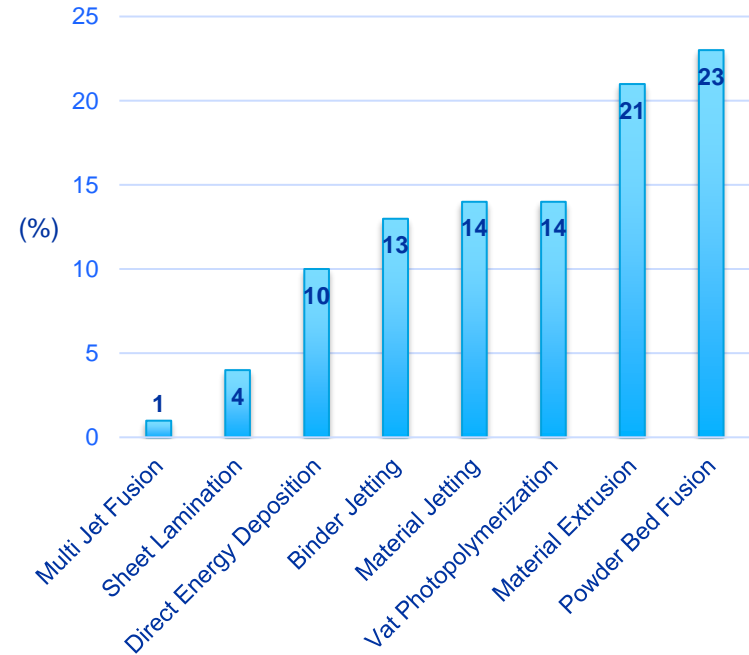
Defense Industrial Base Suppliers



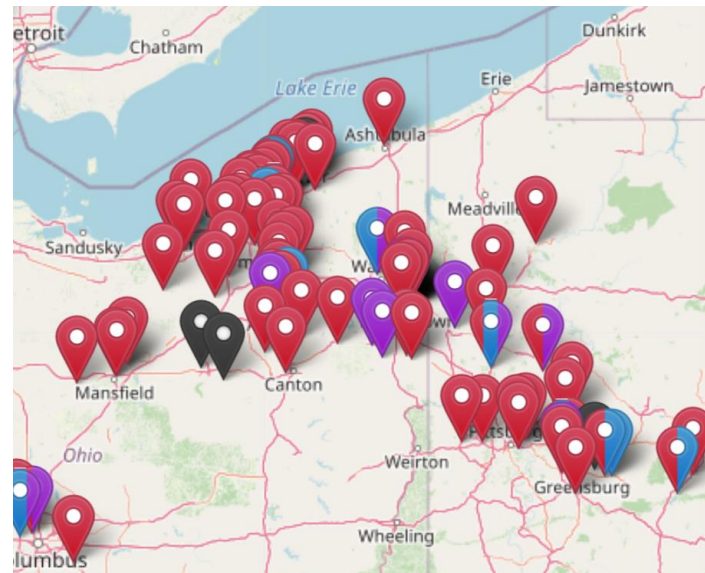
Supplier Role



Printers' AM Process



Supplier Location by Role



Location	Registration
OH	111 (52%)
PA	32 (15%)
Other	69 (33%)

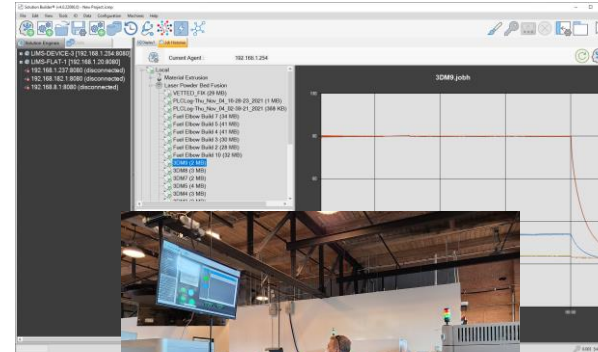
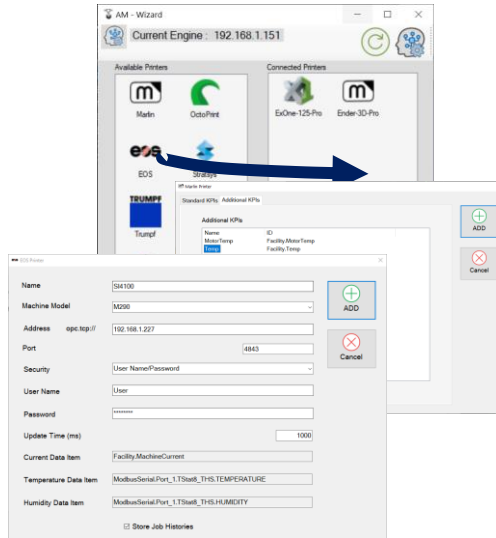
Edge Device to AMIP Integration Process

Step 1:
Prepare
Machine

Step 2:
Run Machine
Wizards

Step 3:
Explore
Job Histories

Step 4:
Upload
AMIP Reports



Uncompromised Security Posture

FIDO Authentication Fast Identity Online

Partner: StrongKey

Demonstrated the use of FIDO tokens as a more secure means of Multi-factor Authentication. FIDO is more secure than other methods such as Text, Email, or Access Card.

STIG Compliance Security Technical Implementation Guide

Partner: DoD

The AMNOW team challenged the AMIP system through Level III STIG's and met all the existing requirements. Currently, there is no STIG compliance guide for IIoT devices (LIMS Edge). The development team worked through existing STIG's and challenged the IIoT device against those individual Level III STIG's that applied to components within the device.

Software-to-Software Encryption

Partner: SecureAge

Demonstrated secure data transfer from client end point through the cloud environment. Additionally demonstrated the ability to keep data encrypted when it is being rendered by an application to the end user. Essentially never presenting the data in clear text to the end user.

28 Total Use Cases Across Multiple Army Commands

Participant Integration

- 15 Army Use Cases
- All Combinations Except HS AI
- Supplier Development and Assessment
- 3D-PDF Tech Data Package Development
- Process Data from Supplier to AMIP
- Simulated Part Qualifications

Advanced Process Development

- 8 Additional Army Use Cases
- 4130, 316L, Al-10Si-Mg, HS AI
- Process Development and Assessment
- Process Data from Supplier to AMIP
- Simulated Machine Operational Qualifications

Prototype Validation

- 5 Additional Army Use Cases
- All Combinations Except 17-4 PH, EPX-82
- Engineering Data from AMIP to Supplier
- Process Data from Supplier to AMIP
- Simulated Part Qualifications

Increasing Data Requirements Throughout Program

Hardware, Testing, and Output Metrics

Totals	Use Cases	Agreement Orders	Builds	Parts	Test Requirements Sheets (TRS)	Tests	Process PCDs	AMS Specifications	Simulated Qualifications
Original	18	~75	~250	~750	110	~1,900	2	0	8 machine & 6 part
Final	28	110	304	2,318	>300	>5,200	3	9	11 machine & 17 part

M-1 Microclimate Vest Manifold



Four suppliers produced these manifold components from glass-reinforced nylon

Part designs were optimized for AM

Equipment: EOS P396 and INTEGRA L-PBF, HP-5210 MultiJet Fusion

Production: More than 540 total parts from 12 builds

CECOM/C5ISR Radar Waveguides



Three suppliers produced these waveguide parts from Al-10Si-Mg

These are on Army's spares list

Equipment: EOS M290, EOS M400-1, GE Concept Laser Xline 2000R

Production: 120 total parts across 12 builds

CH-47 Cargo Door Link



Two suppliers produced these parts from high-strength aluminum

Original forged designs were prone to failure in the field

Equipment: EOS M290 for 7A77, GE Concept Laser M2 for Scalmalloy

Production: 16 total parts were produced across 4 builds

Shadow UAV Jack Stand



Six suppliers are producing jack stands from ULTEM 9085, PETG, PLA

Part designs were optimized for AM with different materials used for field durability evaluation to reduce maintenance and downtime

Equipment: Stratasys F450 and F900

Production: 24 total parts from more than 6 builds

CH-47 Fuel Sampler Tool



Eight suppliers produced fuel samplers from 316L

These address an ergonomic and safety issue

Equipment: EOS M290, EOS M400-1, SLM 280/2, Renishaw AM-400, GE Concept Laser M2

Production: 48 total parts across 8 builds

M109 Thermostat Housing



Five suppliers are producing these parts from Al-10Si-Mg

Original castings with long lead times and logistic concerns

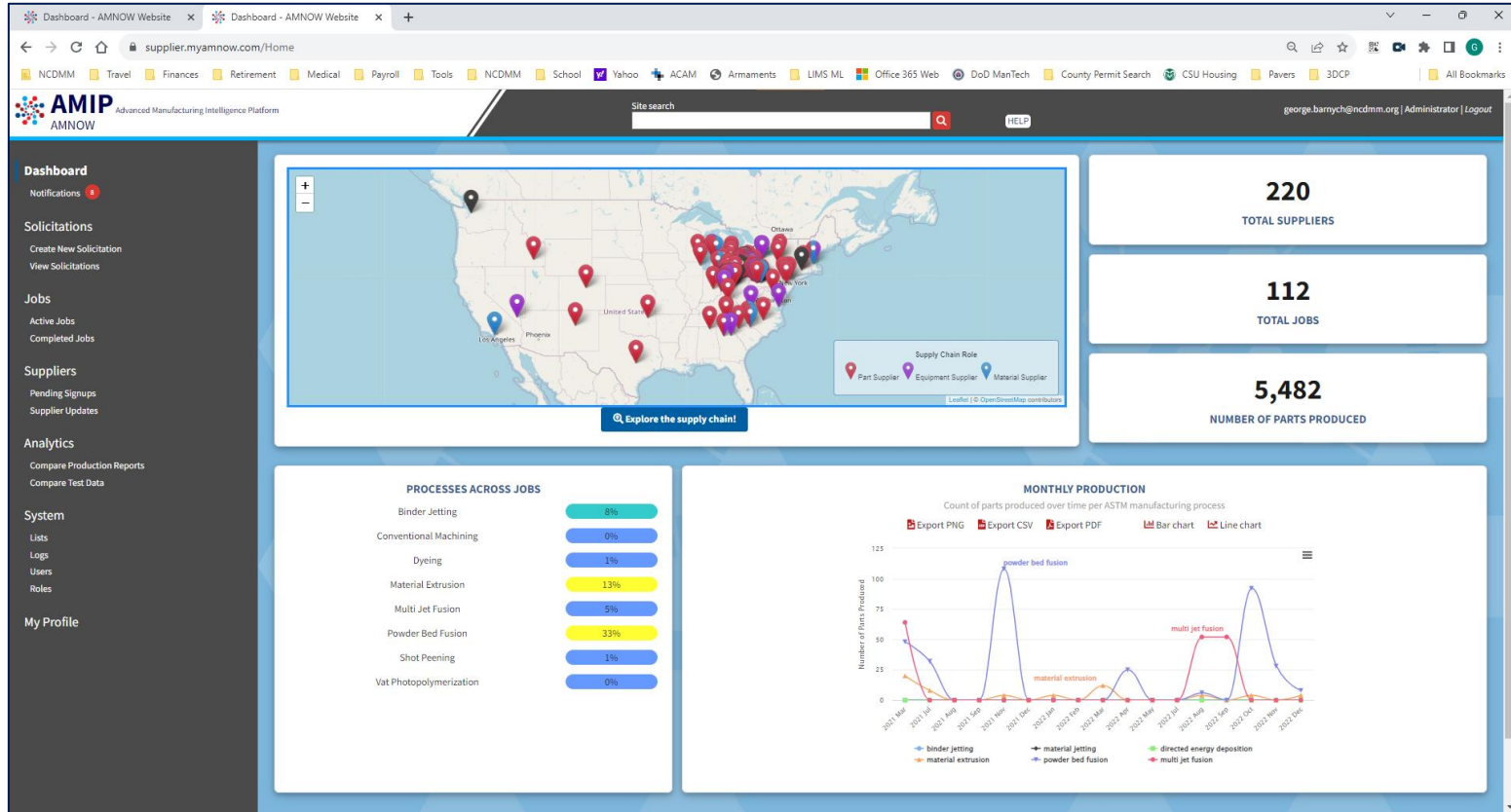
Equipment: EOS M290, M400-1, SLM-280/2

Production: 30 total parts were produced across 13 builds

AMIP Functions and Features

- Intensive detailed database of suppliers listing specific capabilities, materials, machines, certifications, qualifications, accreditations, locations and other
- Search for capable suppliers based on any combination of criteria listed above
- Initiate the RFP process and provide TDPs through a highly secure digital thread
- Initiate digital representations of “jobs” once the contracting process is complete
- Receive contracted digital data deliverables
- Use integrated visualization tools to determine part and it’s associated digital data deliverables “acceptance” and receive a digital data certificate of conformance
- Use integrated visualization tools to compare digital data deliverables across multiple previously delivered “job” data
- Use integrated visualization tools to assess supply chain performance
- Securely download cloud data to your secure intranet (purge if you want)

All transaction histories retained indefinitely



BACKUP

LIMS “Surrounded by Standards”

Manufacturing Analytics – Results via MTConnect®

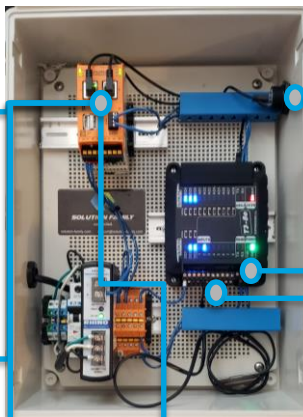
- OEE
- Inspection – PC DMIS, NIST QIF, Direct Gauging
- AZURE & AWS – Machine Learning
- Native Python on device Machine Learning

Database/Cloud Integration

- **Databases** – GraphQL, SQLite, MySQL, Microsoft SQL, Oracle
- **AWS** - DynamoDB, RTS, Sagemaker, Quicksite, GreenGrass
- **Azure** – Azure Tables, Power BI
- **Clouds** – AWS, Azure, Hitachi, Eurotech, Dream Factory
- **Dashboards** – Prometheus, Grafana, PowerBI

Application Platform

- Debian 11 – Open Source
- Development Languages – C,C++,C#, Python, NodeRED, logi.CAD3
- Real Time Extension (PREEMPT-RT)
- Solution Engine®
 - Zero Programming. Rules, Analytics, Data, Cloud, Job Histories



Connectivity - Ethernet

- **Physical** - Dual Ethernet Connections for Data Network - IO Network Isolation
- **MTConnect®** – All Appliance Data Available
- **Native Adapters** - HAAS, Okuma, Mori Seiki, Mazak, Mitsubishi, Fanuc
- **Industrial IO Networks**
 - Modbus TCP, OPC UA, PROFINET, Ethernet/IP, SERCOS, DeviceNet, CANOpen, CIP, EtherCAT, ABB, Kuka, UL
- MQTT, LABVIEW, snap7, OpenPLC

IO

- RS485 – Modbus RTU CAN Open
- Analog – 4/20 ma, 0-10V, 0-5V, Thermistor, RTD, CT
- Digital – Contact Closure, Relays
- High Speed Counters / Relay Outputs

Machine Interface Automation

- **Additive** – EOS, Stratasys, Trumpf, Desktop Metal, ExOne, OctoPrint, GE, Marlin (99% Desktop Printers)
- **Subtractive** – Fanuc, HAAS, Mori, Mazak, Okuma, Mach4

REST Connectivity

- Solution Engine® SDK – REST Interface
- GitHub - Open Source
 - Python
 - C#
 - JavaScript

Grafana – Turn Key Dashboards



Platform for Applications

- OEE - Provides Automated Production
- Real Time Dashboards
- Analytics - Lowers Cognitive Load for Operators
 - Finger Print Initial Production
 - Recognizes when machines changes signature
 - Notify Operator
- Vibration Monitoring



Binder Jetting - Job History Data Origins (35 KPIs)

Controller



Make	PrintHeadBinder LVL
Model	PrintHeadBinder Low
Serial #	Status COLOR
Calibration Date	Print Status
Control Software Rev	Recoater Powder LVL
Bed Temperature	Recoater Power Low
Layer	RecoaterHopper LVL
Total Layers	RecoaterHopper Low
Binder Level	Vacuum Level
Binder Level OK	Waste Level
Cleaner OK	Waste Full
Layer Height	

Environment

Current 

Shop Temperature

Shop Humidity 

LIMS - Analytics

Layer Height
Job KWH
Avg Shop Temp
Avg Shop Humidity
Part Start Time
Part End Time
Part Time

Part Counter
Avg KWH
Utilization
Avg Utilization
Running
Efficiency
Avg Efficiency



CNC- Job History Data Origins (54 KPIs)

Controller



- Make
- Model
- Serial #
- Make
- Model
- Control Software Rev

- Machine Status
- Block #
- Block
- Tool ID
- Part File

- Feed Override
- Feed Rate
- Feed Commanded

- Axes (X,Y,Z,A,B,C)....
- Actual Pos
- Commanded Pos

- Spindle
- Spindle Speed
- Speed Override
- Spindle Commanded
- Speed Override



Environment

- 3 Phase Power
- Coolant Temp
- Spindle Case Temp



- Shop Temperature
- Shop Humidity



LIMS - Analytics

- Job KWH
- Avg Shop Temp
- Avg Shop Humidity
- Part Start Time
- Part End Time
- Part Time

- Part Counter
- Avg KWH
- Utilization
- Avg Utilization
- Running
- Efficiency
- Avg Efficiency

